APPENDIX 24

Comments of the
Virginia Association of Municipal Wastewater Agencies, Inc.,
and
Maryland Association of Municipal Wastewater Agencies, Inc.

on

Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for Chesapeake Bay and its Tidal Tributaries
(Third Draft, December 2, 2002)

submitted to:

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Chesapeake Bay Program Office
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1. INTRODUCTION

The Virginia Association of Municipal Wastewater Agencies, Inc. ("VAMWA") and the Maryland Association of Municipal Wastewater Agencies, Inc. ("MAMWA") are non-profit local government associations dedicated to protecting public health and the environment based on sound science in the most efficient manner possible. Together, these two Associations include nearly every major municipal wastewater treatment operation in Virginia, Maryland and the District of Columbia.

VAMWA and MAMWA have long been active in the restoration of the Chesapeake Bay. For example, each Association supported the adoption of state grant programs to assist localities with the design and installation of biological nutrient removal technology at municipal wastewater treatment plants. Many of our members have participated in these partnerships to achieve nutrient reductions.

The U.S. Environmental Protection Agency's current effort to establish water quality criteria will have significant implications for the citizens of the watershed and their governments beyond guiding the enhancement of water resources. The criteria have the potential to dictate the need for, and the timing of, hundreds of millions or possibly billions of dollars in capital upgrades at municipal wastewater treatment plants (and comparable investments by other sources of nutrients), and affect the allocation of limited taxpayer resources and economic growth and development throughout the region.

Given the significance of these criteria, VAMWA and MAMWA have made it their highest priority over the past two years to support the use of sound science in the criteria development process principally through the involvement of our water quality scientists. We appreciate the opportunity to participate in the overall effort as well as the specific opportunity to review and comment on the third draft of the criteria document.

We look forward to EPA's response to these comments. In the meantime, please feel free to direct any questions regarding our comments to Norman LeBlanc at (757) 460-4243 or nleblanc@hrsd.com.

SECTION 2. SPECIFIC COMMENTS ON CHAPTERS

2A. Water Clarity—Chapter IV

V/MAMWA continues to support the development of the water clarity criteria. Credible research has been cited to quantify relations between water clarity and the potential for SAV survival and growth. Historical increases in water clarity—some of which were due to management actions—have been shown to directly benefit the aquatic life use. We support the use of water clarity as a key management variable for the Chesapeake Bay and tributaries. The sharp contrast between these comments on water clarity and those associated with chlorophyll a should demonstrate that our association can support the development of new water quality criteria provided that the technical basis is reasonable. However, we have several comments that we believe are important to the successful framing and implementation of this criterion. In parallel with these comments, we have provided recommended edits to the text in Section 3.

1. The criteria should be expressed as percent-light-through-water only. From a mechanistic standpoint, epiphytic growth can be an important component of the total light attenuation. But from a regulatory standpoint, PLL-based criteria are not an improvement over the PLW-based criteria, introduce unnecessary complexity, and are prone to be misapplied. As discussed by the clarity team, PLW has been shown to be an equally valid predictor of SAV distribution as PLL; the additional consideration of leaf-surface attenuation does not appear to provide significantly more explanatory power compared with PLW alone. There are many areas where epiphytic growth is a non-factor in total light attenuation and the use of PLL would result in erroneous predictions. For example, Moore and others (2000) found that the PLL algorithm significantly overpredicted leaf-surface light attenuation in the tidal freshwater James River.

In chapter VI (Recommended Implementation Procedures) of the criteria document it is stated that "the light-through-water criteria should be applied to all the shallow-water bay grass designated use habitats unless there is a compelling reason to apply the light-at-the-leaf criteria." (p. 132). The document does not provide any technical assistance to assess what is a *compelling reason*. Although we appreciate this acknowledgement that the PLW-based criteria are preferable, in practice the states are likely to adopt the criteria as given in Table IV-2, and the preference for the PLW-based criteria may be lost. Regardless, it will be difficult for environmental managers to judge where PLL-based criteria would provide any benefit over PLW-based criteria. Thus, there is no "compelling reason" to include the PLL-based values as 304(a) criteria in the first place. Another valid reason to exclude the PLL determination from the regulatory criteria is due to the extra expense of nutrient and TSS data collection needed in the shallows for the calculations, especially since little or no additional significance would be added to the interpretations. We recommend that the potential for epiphytic growth be acknowledged in the document, along with a reference to the SAV Technical Synthesis 2 work on the topic. It should be stated that the criteria are based on PLW because it is an equally-valid predictor of SAV coverage and better-validated parameter. Our recommended edits on p. 90-93 reflect this judgment.

2. *Old habitat requirements should be removed from the chapter.* Table IV-1 (p. 89) provides a list of non-regulatory habitat requirements from the 1992 and 2000 SAV technical syntheses. It includes "requirements" for total suspended solids, chlorophyll *a*, dissolved inorganic phosphorus, and dissolved inorganic nitrogen. Although the document does not label these values as "criteria", we do not believe these values are appropriate in a 304(a) criteria document for water clarity and should be removed from the document. Although they should be retained in the second technical synthesis, these values were never intended to be applied in any regulatory context, and were not based on the same standard of science that would be required for 304(a) criteria. These values should not be directly used in assessing attainment with the water clarity criteria, and thus they do not add value to this chapter. Our recommended edits reflect this judgment.

3. The water clarity criteria may be overprotective in low salinity waters. There is a conspicuous mismatch between non-attainment of the water clarity criteria and the presence/increase of SAV that leads one to believe that the criteria could be overprotective in tidal freshwater and oligohaline segments, as it is currently proposed to be implemented. The mismatch is noted in this chapter (p. 81) by reference to Batiuk and others (2000), who noted that in tidal freshwater and oligohaline segments:

- The median values of percent light-at-the-leaf at the 0.5 meter and 0.1 meter depths were "far below the minimum light requirement" in low-salinity segments that supported SAV at those depths.
- Positive increases in bay grasses occurred in low-salinity segments "even when the median percent light-through-water was considerably less than the minimum requirement."

Some of the potential reasons for this mismatch include:

- The criteria itself (13 percent light through water) may exceed the actual light requirement of many freshwater SAV taxa.
- Canopy formation allows many SAV taxa to concentration their photosynthetic tissues much higher in the water column than the total water depth that would be used in equation IV-1 (p. 86).
- Established grass beds require less light than is needed for the revegetation of barren areas.

We understand and support the intention to derive criteria that are protective of a wide variety of SAV species, not just canopy formers or those with lower light requirements. We raise this issue here because the mismatch between criteria attainment and SAV growth/survival has the potential to be a major regulatory problem for segments that have abundant, persistent, and diverse SAV yet do not attain the clarity criteria. For such segments, there needs to be a modification in the either the criteria, the effective depth of application, or the assessment methodology. Our opinion at this time is that the issue would be better addressed through modification of the assessment methodology or depth of application than the water clarity criterion itself. Our comments on Chapter VI (Recommended Implementation Procedures) elaborate on this topic and provide specific recommendations.

4. Additional comments

Figure IV-1 (pp 77): This figure provides a conceptual diagram of light effects on SAV. The title should be re-labeled as "….light/suspended sediment-nutrient effects…." instead of reference only to nutrients. This change is appropriate given the large role of suspended sediment on reducing water clarity. The revision has been noted in the recommended edits. This figure should also be revised to include sediment re-suspension as a process which leads to greater suspended sediment.

Validation of Predicted vs Actual Bay Grass Restoration (pp 81): This section provided an editor's note that an updated set of validation results – 1985-2001 will be incorporated into the final criteria document. This should be expanded to capture and elaborate on the significance of the 2002 drought on SAV resurgence. This phenomenon serve to further validate the role of improving water clarity on the abundance of bay grasses. It also shows the critical importance of controlling the non-point sources of suspended sediment in particular.

References

Batiuk, R. A., P. Bergstrom, M. Kemp, E. Koch, L. Murray, J. C. Stevenson, R. Bartleson, V. Carter, N. B. Rybicki, J. M. Landwehr, C. Gallegos, L. Karrh, M. Naylor, D. Wilcox, K. A. Moore, S. Ailstock and M. Teichberg. 2000. *Chesapeake Bay Submerged Aquatic Vegetation Water Quality and Habitat-Based Requirements and Restoration Targets: A Second Technical Synthesis.* CBP/TRS 245/00 EPA 903-R-00-014. U.S. EPA Chesapeake Bay Program, Annapolis, Maryland.

Moore, K.A., Orth, R., and Fishman, J. 2000. Restoration of Submerged Aquatic Vegetation (SAV) in the Tidal Freshwater James River: 1999 Pilot Study. Special Report No. 365 in Applied Marine Science and Ocean Engineering. 21 p. plus figures

2B. Chlorophyll *a* Criteria – Chapter V

I. General comments - chlorophyll *a* criteria

It seems appropriate to begin our comments on this chapter with a brief synopsis of chlorophyll *a* criteria development efforts and issues that have evolved to date. The first draft of the document (July 2001) emphasized the "Phytoplankton Reference Community Approach" along with other secondary sources of information such as historical values, literature values, and contributions to light attenuation and low dissolved oxygen. After the first review period it was recognized that this primary line of evidence (phytoplankton reference communities / water quality binning) lacked a sufficient linkage between chlorophyll *a* and designated uses.

In an attempt to correct this problem further analyses were conducted toward a possible linkage between chlorophyll *a* and mesozooplankton abundance. The resulting second draft of the criteria document (May 2002) emphasized these "food quality" connections as the next primary line of evidence. We supported that approach and provided data analysis to assist in the effort. Although this method seemed promising at first, a significant number of adverse review comments were received from a wide range of other reviewers including ourselves and STAC. These developments led to the development of the present draft (December 2002) from which the food quality approach was removed as a primary line of evidence with a recommendation for further research and development.

What remains is largely a repackaging of earlier discussions of trophic classifications and reference conditions that shows no significant improvement in making the necessary connections with designated uses, and not support numerical 304(a) criteria. Of the remaining lines of evidence, the only one that attempts to relate numerical chlorophyll *a* values to designated uses is that related to the potential harmful algal blooms. Although this is an important consideration, further review of the literature and plankton monitoring data indicated that the associated numerical chlorophyll *a* criteria values were not supported, the cited bloom densities do not necessarily represent use impairments, and practicality of addressing most HABs by chlorophyll *a* management is highly questionable.

Our recommendation for righting the course consists of moving forward with a narrative chlorophyll *a* criterion alone and publishing the remainder of the technical information in a separate non-regulatory proceedings document. This approach will preserve the work to date and provide a basis for continued work in the investigation of relationships between chlorophyll a and designated use impairments. It is recognized, however, that States will need guidance in developing translators to interpret a narrative criteria. To fulfill this need, we recommend that greater consideration be placed on aesthetics and connections with attainment of water clarity and dissolved oxygen criteria. We also recommend an adaptive management approach for chlorophyll *a* that allows states to monitor components of the narrative chlorophyll *a* criterion (DO, clarity, HABs, aesthetics, etc.) and periodically reevaluate the need for specific numeric chlorophyll *a* targets.

Table V-10 is of particular concern because it serves to consolidate the contents of Chapter V. Consistent with our comments and recommendations it should be extensively modified to reflect the following: (1) the chlorophyll a criteria consists of a narrative only, (2) the concentration data shown on the table reflect generalized conditions and do not indicate impairment thresholds to designated uses. As such, they do not represent agency recommendations for numerical criteria under the 304(a) program, and (3) States are encouraged to evaluate the roles of chlorophyll a on water clarity, dissolved oxygen, aesthetics, and/or other pertinent site specific issues their efforts to interpret the narrative criterion. Our recommended language associated with these revisions are provided in Section 3 of these comments.

Background (pp 98-99)

This section contains some useful background material. However, it is also potentially misleading in that it implies chlorophyll *a* has been shown to be a useful indicator/management variable for food quality and HABs. We have recommended some edits and reorganization to this section to (1) emphasize the well-founded linkages between DO and clarity; (2) mention the association between chlorophyll *a* and aesthetics; and (3) be up-front about the uncertainties regarding connections between chlorophyll a, food quality, and HAB management.

Approach to Deriving Chlorophyll *a* Criteria (pp 98)
Chlorophyll *a* concentrations characteristic of desired ecological conditions (pp 99)

a. Comments on trophic classification approach

These sections rely on trophic classifications that are much too weak to support derivation of 304(a) water quality criteria. The approach involved two critical assumptions (1) biological impairments can be neatly divided and captured by classification of waters into four trophic categories; and (2) measured chlorophyll *a* values can be used to assign specific waters into these classifications. The implication is that if chlorophyll *a* values exceed the ideal of mesotrophic conditions, then the biology must also be assumed impaired by association. These assumptions are not supported by data and we cannot accept them due to the following factors:

<u>The classification of ecological conditions within trophic classifications was highly subjective</u>: Table V-1 is a very important element in the criteria document because, as stated in the text, it served to *"frame the connections between algal growth and productivity, the various ecological and water quality consequences and, ultimately designated uses for the Chesapeake Bay."* Table V-1 provides a listing of various biological conditions / impacts and assigns them to oligotrophic, mesotrophic, eutrophic,

and highly eutrophic classes. However, there was no technical basis provided to support the rationale for their placement into these specific categories. We found the resulting classifications too subjective and general for drawing associations between algal growth and designated uses.

Biological impairments that are claimed to occur due to shifts in trophic status cannot be explained by chlorophyll *a*: We do not dispute the general concepts associated with the trophic continuum. This widely accepted ecological concept holds that increasing nutrient enrichment can lead to higher primary production which, if severe enough, may lead to the type of biological impairments described on Table V-1. Our point of contention is that the different ecological impairments described in Table V-1 cannot be easily categorized (as discussed above) or quantitatively explained by chlorophyll *a*. Because chlorophyll *a* is an indicator rather than a direct stressor, it cannot differentiate between nutrient enrichment and impairments of designated uses. The document fails to show any convincing, quantitative relationships between chlorophyll *a* and the ecological impairments contained on Table V-1.

For example, there is no evidence that any of the impairments listed under the eutrophic category occur when spring chlorophyll *a* exceeds 6 μg/L (listed in Table V-10 as protective of mesotrophic conditions) in mesohaline waters. Depending on the segment, the impairments might occur at much higher chlorophyll *a* concentrations, not at all, or in a manner that has no direct relation with chlorophyll *a* concentration.

In summary, Table V-1 and associated text represent a highly general, qualitative discussion of ecological concepts. It could be useful in some contexts, such as general education on the types of ecological functions that might occur as water bodies are enriched. However, it does not demonstrate quantitative relations between chlorophyll *a* and impairments, and should not be directly used to derive numeric chlorophyll *a* criteria.

b. Comments on management by salinity regime

The criteria development involves a proposal for different chlorophyll a criteria by salinity regime (tidal fresh, oligohaline, mesohaline, and polyhaline). In general we agree that chlorophyll a criteria should be addressed in this manner. However, the polyhaline segments for Mobjack Bay (MOBPH), York (YRKPH) and James River (JMSPH) should be managed differently than the main stem Bay segments (i.e. CB8PH, CB7PH, CB6PH). Due to the natural estuarine gradient, nutrient concentrations and the resulting chlorophyll a concentrations are greater in the lower tributaries than in the main stem Bay. This can be attributed to closer proximity to land based freshwater flows and a greater distance from oceanic inputs. For example, although the lower James River (JMSPH) is strongly influenced by lower Bay conditions, it should not always be expected to exhibit chlorophyll a conditions consistent with the Bay mouth (CB8PH) for these reasons. During wet weather conditions a greater nutrient load delivered to the lower James River would result in greater chlorophyll a concentrations than would be observed at the bay mouth even in the absence of anthropogenic sources of nutrients. We recommend that the above referenced lower tributary segments geographically classified as "polyhaline" in the CBP segmentation be managed as mesohaline with respect to future criteria application. Only the lower main stem Bay segments should be considered consistently polyhaline with regard to chlorophyll a values using the geographical basis for management.

Historically observed concentrations (pp 101)

Historical chlorophyll *a* data are considered valuable because they offer the only available means to characterize past conditions. However, we view these data as very limited and unsuitable for the derivation of water quality criteria for a number of reasons. From the beginning of the chlorophyll *a* criteria development effort we have provided comments associated with general concerns over the use of the historical (pre-1985) water quality data. Although this line of evidence has persisted in the criteria document since the beginning, our concerns over this piece are greater at this time as it seems that it has taken on a greater significance.

Our most fundamental concern with the historical data approach is that it does not define impairments of designated uses. Even perfect knowledge of what concentrations were at some point in the past does not allow us to identify the concentrations above which impairments occur, nor does it demonstrate a direct relation between chlorophyll *a* and those impairments. Criteria derived by reference to some past condition could be highly overprotective or simply ineffective.

Our second concern related to historical data is associated with the spotty / infrequent nature of the data collections and questions regarding their representative nature. To further investigate this issue the data set of Harding and Perry (1997) was evaluated relative to the number of sampling events, decadal temporal coverage, and other issues. This analysis was performed to reach a more detailed understanding of the data distributions. This analysis can also be found in our comments on the preliminary draft (dated August 2000). It should be noted that the results of our analysis and Table V-2 are not in conflict. Rather than the number of observations which are reported (Table V-2), our analysis focused on the number of sampling *events*. This approach was taken since multiple samples collected on a given sampling event tend to yield similar results. That analysis indicated the following:

<u>1950s decade</u>: The number of sampling events recorded during the 1950s decade was consistently less than five for all of the region combinations investigated with the exception of the region #3 summer combination which had intensive monitoring between June and July 1951. In many cases the number of field events in this decade were as low as a single event and were zero for region #2 and region #4 summer combinations. The lowest number of sampling events was observed for region #4 where the fall, spring, and winter seasons were represented by a single sampling event with none collected during the summer months. The temporal coverage was consistently low and ranged from 3% to 6% of the possible combinations for the decade.

The 1950s data set appears to contain too few independent sampling events to reliably represent conditions during that decade for any of the regions. The paucity and/or absence of data for that decade is of a concern because it brings into question the validity of comparing annual means between that period and those of contemporary measurement. Furthermore, the 1950s data appear to be skewed artificially low relative to recent data due to (1) the inability to capture periodic bloom conditions. Bloom conditions were invariably missed because approximately 95% of the decade was not sampled; (2) few spring and summer data were collected. Higher chlorophyll means during the 1980-1990 decade compared to the 1950s could therefore be due, at least in part, to the failure of the data collection to adequately capture the those seasons; and (3) a review of the minimum values suggests that the 1950s data were reported relative to lower detection/reporting limits than the more recent data (i.e. 0.1 µg/l vs 1.0 µg/l for the 1990s). This may also serve to lower the averages of the 1950s relative to contemporary measurements.

1960s decade: The 1960s decade generally contained a similar number of sampling events as the 1950s time frame for regions #1-#3 (lower Bay). In region #1 the number of field events were less in the 1960s than the 1950s. However, in regions #4 through #6 the number of sampling events were generally greater than 10. Overall, the temporal coverage ranged from 4% to 33%. Regions #4 - #6 contained the greatest coverage in the decade and ranged from 20-33%. The lower bay Region #1 was sampled only during the year 1969 for this decade. It is quite notable that 3 of the 5 the monitoring events during 1969 (October-December 1969) were on months immediately following hurricane Camille which occurred August 14-22 1969. Hurricane Camille produced record levels of torrential rains and flash flooding in the James River system, and represented Virginia's worst natural disaster (re: NOAA's Virginia hurricane history, http://www.hpc.ncep.noaa.gov/research/roth/vahur.htm.). For this reason, the 1960's data are not considered representative in Region #1.

The 1960s data set also appears to contain too few observations to reliably represent conditions of that decade for reasons similar to those described for the 1950s for regions #1-#3. Conditions in the upper bay for regions #4 - #6 are somewhat better given that 20% or more of the decade was sampled and that the seasons of spring and summer had 10 or more sample collections within the decade. Given that Region #1 contains mostly data collected immediately after hurricane Camille, this region's chlorophyll data for the 1960s must be considered unrepresentative as well infrequently collected.

1970s decade: The decade of the 1970s generally contained a much greater number of sampling events than the 1950-1960 time frame. However, region #2 was characterized by the less than 10 sampling events for each of its decade and season combinations. The temporal coverage ranged from 15 to 83%. Similar to the 1960s there was more temporal coverage in the upper Bay than in the middle and lower Bay regions. The 1970s decade was reasonably well represented with the exception of region #2. The data sets for 1980-1994 was consistent and reliable.

1980s and 1990s decade: Sampling events were numerous with consistent temporal coverage. Temporal coverage consistently exceeded 60% in the 1980's with near 100% coverage in the 1990s. The years spanning 1983-1994 were consistently represented.

Ensuring appropriate quality assurance with regards to data and methods represents an established aspect of the water quality criteria / standards development process. Various guidelines for evaluating data can be found in EPA (1985) and EPA (1997). Although the 1985 through the present data set represents known quality data generated under a quality assurance plan, the data quality of the pre-1985 data set is of concern.

The role of historical levels of filter feeding grazers also should be taken into consideration when comparing chlorophyll *a* values of the past with contemporary measurements. Fisheries catch data indicates that two important filter-feeding species (the menhaden and the oyster) were in much greater abundance during the 1950s-1960s than during present times. Potentially lower chlorophyll *a* values of the past (if genuine) probably reflected to some degree the greater ability of these dominant species to consume algae. The Chesapeake 2000 Agreement includes a commitment to evaluate the effects of such species on water quality. The role of biology and its effects on chlorophyll a values should be more carefully considered in the process in a manner consistent with the Bay goals.

Benchmark levels derived from analysis of the CBP water quality data base (pp 107), Appendix E (pp E-1)

The benchmark analysis should also be viewed as valuable information regarding existing and past concentration of chlorophyll *a*. However, the historical data (pre-1984) draws from the same source of information as Harding and Perry (1997). A review of the tables in Appendix E clearly supports our previous concerns over the paucity of data in the 50's and 60's particularly for the lower Bay and its tributaries. Therefore, our concerns regarding these historical data are the same as stated in the previous section.

The benchmark analysis employed the methods described by Alden and Perry (1997) was used to develop "poor", "fair", and "good" water quality conditions. These rankings were not based on "effects" but simply reflect the statistical distribution of data along percentiles. These methods have been useful in developing Chesapeake Bay reports intended to generally characterize water quality but they were never intended to be used as a basis for development of regulatory chlorophyll *a* criteria. To use this approach would deviate from effects-based criteria to one derived from percentiles. The present Bay Program approach should follow an effects-based methodology instead of shortcuts that bypass an understanding of effects.

Literature values related to trophic status (pp 101)

The referenced literature values related to trophic status do not provide a linkage between specific biological impairments (i.e. designated uses) and chlorophyll *a* to allow their use in establishing chlorophyll *a* criteria for Chesapeake Bay. Similar to historical concentrations and benchmark analysis they serve to provide very general information concerning status but clearly lack a basis on "effects". Further, the focus of these papers were largely on lakes / reservoirs, (Ryding and Rast, 1989; Wetzel, 1985; and foreign waters (Molvaer, 1997; Smith, 1998). A review of Smith (1998) indicated that the basis of the 1-3 ug/l for polyhaline waters was derived from a table for marine waters. Although this level of chlorophyll a would be reasonable for open ocean marine conditions, the polyhaline areas of the Chesapeake Bay (i.e. lower Bay) should not be expected (nor considered desirable) to have chlorophyll *a* to levels at or near the analytical detection limit. They are obviously in too close proximity to freshwaters and natural land based nutrient sources to be considered a marine ecosystem.

Phytoplankton reference communities (pp 101), (Appendix F)

The phytoplankton reference community connections represent a primary basis of support claimed for the chlorophyll *a* criteria contained on Table V-10. This particular approach was the major focus of our comments related to the first criteria version (July 2001). Our comments at that time as well as those submitted by others expressed a strong need to relate chlorophyll a to designated uses that was lacking in this approach. This development led to successive attempts to directly relate chlorophyll *a* to plankton indices such as mesozooplankton (i.e. food quality) described in the second version. Unfortunately, these approaches were largely unsuccessful in making these connections. Given this situation, it should be concluded that the phytoplankton reference community approach is not an appropriate basis for numerical chlorophyll *a* criteria relative to effects.

Our review of this section indicates that the description and support for the phytoplankton community based criteria values was significantly abbreviated since the first draft, but the overall basis remained the same. Therefore, we will re-iterate the major points of those comments for this version. It is apparent that a sufficient linkage between chlorophyll *a* and designated uses (such as plankton assemblages and/or upper trophic levels) has not been made to support the proposed numerical criteria. In order to successfully accomplish this objective we believe that two critical elements were lacking including (1) objective definitions of " "impaired" and "non-impaired" levels of plankton-related indices, and (2) an investigation of the direct relationships between those indices and chlorophyll *a* concentrations. Instead, the approach sought to define "reference plankton communities" indirectly on the basis of generic water quality instead of directly basing chlorophyll *a* criteria on target plankton indices / designated uses. There is a critical difference between the two and the former is not an acceptable substitute for demonstrating that chlorophyll *a* is a useful indicator of and management variable for specific impairments.

The use of water quality "cutoffs" and subsequent water quality "binning" procedures as described led to a categorization approach that was subjective and excessively value laden. Combinations of different parameters of various magnitudes (DIN, PO4, and Secchi depth) into single categories (i.e. poor, better, mixed etc.) made it very difficult to develop an understanding of the controlling variables.

Appendix F (Table F-3) contains a chart of the average taxa biomass as a percentage of total nano-micro phytoplankton biomass for the water quality conditions considered reference. However, what the present document does not show are (1) the results associated with the other water quality conditions or (2) an explanation as to why the taxonomic composition can be considered impaired in relation to chlorophyll *a*. As previously mentioned, the supporting information associated with this line of evidence was considerably abbreviated since the first draft. The original figures showed the relationships between water quality and plankton indices. These data showed inconsistent and inconclusive relationships between biomass of taxonomic groups and the different water quality bins.

Merely suggesting that different water quality categories have different plankton characteristics and different average chlorophyll *a* concentrations does not demonstrate that chlorophyll is a useful predictor of or management variable for these plankton characteristics. Even if the differences between categories were statistically significant (which has not been demonstrated), high natural variability and the influence of other variables (e.g., light) may make chlorophyll *a* very poor predictor of many plankton characteristics. Although many plankton-related variables would be expected to correlate with chlorophyll *a*, the relations probably will not become apparent except over much higher chlorophyll *a* concentrations than were considered in this approach.

Moreover, there was no demonstration that plankton communities in the different bins either do or do not represent aquatic life impairments. Bins labeled "poor" or "worst" on the basis of nutrient/light availability are not necessarily less capable of supporting higher trophic levels than bins labeled "better" or "best". For example, statistical hypothesis testing of water quality and plankton monitoring data has demonstrated that, despite certain correlations between chlorophyll *a* and some phytoplankton taxa, chlorophyll *a* is <u>not</u> a statistically useful indicator of mesozooplankton abundance (VAMWA, 2002).

The root of the problem seems to lie with a mismatch between the previous objectives intended for the phytoplankton goals workgroup (related to voluntary *goals*) and the demands of a 304(a) water quality criteria program (related to *enforceable criteria*). The two objectives are not the same and are not considered interchangeable.

Chlorophyll *a* concentrations characteristic of potentially harmful algal blooms (pp 111)

We appreciate the efforts to link chlorophyll *a* concentrations to specific aquatic life impairments such as harmful algal blooms (HABs). As the authors are aware, HAB occurrence is a complex, incompletely-understood phenomenon. The practicality or non-practicality of managing HABs is an interesting research topic that merits more investigation. Although this section represents a valuable compilation of information, for reasons given below this line of evidence does not support numeric 304(a) chlorophyll *a* criteria. We recommend further research on this topic. In the meantime, HAB frequency and magnitude should be monitored in parallel with the large nutrient load reductions that will be implemented to achieve DO and water clarity standards.

Figure V-2 represents a plot of phytoplankton food composition and chlorophyll *a* concentration for the summer mesohaline condition. The authors conclude that (1) harmful or nuisance species tend to be associated with high chlorophyll a concentrations and (2) the fraction of total phytoplankton biomass comprised of dinoflagellates and cyanobacteria increases as chlorophyll a increases while diatoms and other taxa decrease. We agree with this finding but only at high chlorophyll *a* concentrations within this specific season and salinity combination. The plot suggests that the potential plankton composition shifts tend to occur at chlorophyll *a* concentrations around 40 μg/l . This concentration is higher than the numerical criteria proposed in Table V-10. Figure V-2 also supports our previous comments regarding the phytoplankton reference community. This graphic clearly shows that plankton assemblages are not discernably different between chlorophyll *a* levels between 0 and 40 μg/l.

Moreover, despite the shift in phytoplankton at chlorophyll *a* concentrations above 40 μg/L, there is no reason to conclude at this time that higher trophic levels are adversely affected even in the summer mesohaline. Statistical hypothesis testing demonstrated that mesozooplankton abundance is not significantly different above and below the chlorophyll *a* thresholds cited in the document (VAMWA, 2002). The chlorophyll *a*-correlated shift in phytoplankton community structure in the summer mesohaline is of scientific interest but has been shown to represent an impairment of designated uses.

***Microcystis aeruginosa* (pp 112)**

It is well-documented from the literature that certain strains of *M. aeruginosa* (as well as many other taxa) can produce toxins or be non-nutritious to certain types of zooplankton. However, there is no evidence that *M. aeruginosa* actually causes aquatic life impairments in Bay tributaries. On the contrary, the available data suggest that *M. aeruginosa* has no negative effect on zooplankton abundance in freshwater regions of Bay tributaries. Total mesozooplankton actually had a positive correlation with *M. aeruginosa* counts in these regions, according to data compiled by members of the Chlorophyll Team (Figure 1).
Statistical hypothesis testing confirmed that zooplankton were significantly *more* abundant when *M. aeruginosa* exceeded the 10,000 mL^{-1} threshold cited in the chlorophyll criteria document than when it did not (VAMWA, 2002). Specifically, the median total mesozooplankton was 12,800 m^{-3} when *M. aeruginosa* was beneath the 10,000 mL^{-1} threshold, and 52,700 m^{-3} when it was above the threshold. In effect, total mesozooplankton are *more* likely to meet the 20,000 m^{-3} threshold that has been cited as a requirement for normal growth of striped bass larva (CBP, 2002) when *M. aeruginosa* exceeds the threshold that is cited in the chlorophyll *a* criterion document as "negatively

affecting zooplankton populations." We do not claim that *M. aeruginosa* is causing the higher zooplankton density—the positive correlation is probably due to an autocorrelation with food abundance. But these data highlight the dubiousness of basing chlorophyll *a* criteria (and, potentially, multi-million dollar load reductions) on the prevention of zooplankton "impairment" by *M. aeruginosa* when no such impairment can be demonstrated in Bay tributaries.

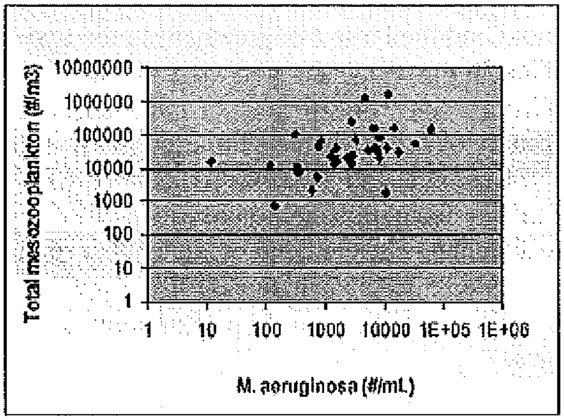

Figure 1.

Similarly, there is no evidence presented that *M. aeruginosa* causes fish kills or other fish impairments in the Bay tributaries. A recent study of fish data collected by the Virginia Department of Game and Inland Fisheries (Malcolm Pirnie, 2002) showed that fish populations in the tidal freshwater James River had "high abundance and diversity…indicating a high quality fish community", despite the fact that *M. aeruginosa* is a common and sometimes abundant taxon in this segment during the summer.

The lack of measurable detrimental field effects of *M. aeruginosa* on fish and zooplankton can be explained by several factors:

1 As stated by Fulton and Paerl (1987), "there are a variety of mechanisms for herbivorous zooplankton to coexist with *M. aeruginosa* blooms." These include resistance to toxins and maintenance of high feeding rates on co-occurring food sources.

2 Studies with mixed zooplankton populations have shown that *M. aeruginosa* has inhibitory effects on some taxa (large cladocerans), some which improves the competitive ability of other taxa such as (smaller cladocerans, copepods, and rotifers (Fulton and Paerl, 1987, 1988; Kurmayer, 2001).

3 Not all strains of *M. aeruginosa* are toxic.

4 Even toxic forms of *M. aeruginosa* do not always produce toxins in high concentrations. Toxin production is known to be maximized during the exponential growth phase, so steady grazing can limit toxin production (Kristen, 1996; Oh *et al.*, 2000; Whitton and Potts, 2000).

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5 Given the uncertainty with respect to the *M. aeruginosa* threshold of impairment (see below), measurable detrimental field impacts might not occur until *M. aeruginosa* reaches blooms levels that are rarely observed or sampled in Bay tributaries.

<u>*Problems with the* M. aeruginosa *threshold*</u>: The 10,000 mL^{-1} *M. aeruginosa* threshold was selected as the geometric mean of two studies (Lampert, 1981; Fulton and Paerl, 1987) that differed by two orders of magnitude as to the threshold of effects. The paucity of studies that allow determination of a threshold and the large disagreement in the two available studies seriously undermine confidence in this value. In fact, the 1,000 mL^{-1} threshold obtained from Lampert (1981) was from a study of effects on a single species (*Daphnia*) only. The Fulton and Paerl (1987) study examined effects on larger number of species and found a threshold of 100,000 mL^{-1}. Even this value was not associated with an overall decline in zooplankton, but a shift in taxa from those inhibited by *M. aeruginosa* to those that gained a competitive advantage. There is no evidence that such this particular variation in the zooplankton structure represents an aquatic life impairment. As discussed above, this threshold did not correspond to undesirable densities of mesozooplankton in Bay tributaries.

The document attempts to shore up the 10,000 mL^{-1} threshold by also basing it on observed *M. aeruginosa* densities in the tidal freshwater Potomac River (p. G-2, Appendix G). The argument appears to be that the 10,000 mL^{-1} threshold is appropriate because *M. aeruginosa* commonly reaches this density in the tidal freshwater Potomac River. Such an observation is irrelevant in the context of selecting a threshold at which uses are impaired. The threshold should be selected only on the basis of demonstrable detrimental impacts.

<u>*Aesthetic aspects of* M. aeruginosa</u>: Although this section does not address the aesthetic aspects of *M. aeruginosa* blooms, nuisance conditions might be a more viable basis for *M. aeruginosa* or chlorophyll *a* thresholds than aquatic life impairments. *M. aeruginosa* is known to be capable of causing bright green scums on the water surface. Importantly, such blooms are known to have occurred in the Potomac River and other locations within the Bay system. What is lacking is quantitative information as to the *M. aeruginosa* or chlorophyll *a* concentrations at which these blooms impair recreational uses in estuarine settings. In other comments we have recommended specific methods for linking chlorophyll *a* concentrations to aesthetic impairments.

In summary, we believe that the work done to date on *M. aeruginosa* is of interest. However, this line of evidence is not yet mature enough to serve as the basis for 304(a) water quality criteria. At this time, the available data suggest that chlorophyll *a* is not a useful predictor of aquatic life impairments from *M. aeruginosa,* and in fact such impairments might not exist in Bay tributaries. We support and encourage further research on both the aquatic life and aesthetic aspects of this taxon. In the meantime, the occurrence of *M. aeruginosa* and other blooms should be tracked as part of an adaptive management strategy for the Bay.

***Prorocentrum minimum* (pp 113)**

A review of Wikfors and Smolowitz (1995) indicated a number of severe problems in the testing procedures that need to be taken into account before drawing conclusions about *Prorocentrum minimum* effects on oysters. In general, we are in agreement that when *P. minimum* was fed exclusively (i.e., alone with no other food sources) the impacts on the oysters appears reasonably consistent with starvation effects. However, we dispute the claims of impact on survival and growth in mixed diets (i.e. those diets that contained both *P. minimum* and the diatom species *Isochrysis*). The specific issues associated with these experiments are explained below:

- The results associated with survival and growth were considered invalid given the very high losses in larvae reported by the authors due to sampling and handling alone. A review of Figure 1 (in this paper) shows that larval losses in the control (T-ISO) were very high and beyond acceptable limits for any toxicitytests used to develop water quality criteria. Therefore, it was not possible to differentiate experimental mortality from unexplained "losses" in this study.

- It was considered inappropriate to arbitrarily select an interval of dates for statistical evaluation (i.e. between days 13 and 17) of growth while ignoring other time periods. The differences in growth observed over the entire exposure period should have been analyzed and reported instead of a selected sub-set of dates. Data review suggests that the conclusions of the paper would be different if other test durations were chosen and compared.

- A review of Figure 2 indicates that shell lengths observed in EXUV (only EXUV) and unfed diets were considerably less than those of the T-ISO, 2/3 EXUV, and 1/3 EXUV diets. However, there appears to be little difference in mean shell length between T-ISO and either of the mixed diets (2/3 EXUV and 1/3 EXUV) over the course of the study and particularly at the end. This observation brings into doubt the results of Table III which report a significant difference in growth rate between the 2/3 EXUV and the 1/3 EXUV diets and the conclusion that impact increases as the percent EXUV increases.

- Histological observation is not an accepted endpoint to establish impact in the context of water quality criteria and standards development. EPA only uses endpoints such as survival, growth and reproduction to develop such criteria. The relationship between this endpoint and the status or predictions of population condition is unknown.

Because of these issues, the results (particularly those involving mixed diet treatments) should not be used to develop water quality criteria.. It is recommended that future studies of oyster larval tests follow accepted procedures to determine the survival and/or well-accepted sub-lethal end-points. The measurement of larval counts over time as opposed to at the beginning and end of the test in this study provided information not routinely available in toxicity tests. However, the experimental methods should be modified to prevent multiple samplings of single replicates to avoid the confounding effects of sampling losses and allow accurate estimates of mortality with each exposure.

A review of Luckenbach et al. (1993) indicates results similar to Wikfors and Smolowitz (1995) in that effects on oysters were evident when *P minimum* was fed exclusively but not in the diets containing both *P. minimum* and diatoms. Figure 1 shows that survival in unialgal *P. minimum* diets at 33% and 100% bloom levels were significantly less than other treatments. However, it is notable that survival in the 50% *P. minimum* and 50% diatom (*Thallassiosira*) were not significantly different than with *Thallassiosira* alone. Similar patterns were observed with growth where unialgal diets of P minimum at 33% and 100% bloom levels were significantly lower than the other treatments. Growth in the 50% *P. minimum* and 50% diatom were not significantly different than with 100% bloom levels of *Thallassiosira*.

A distinction of impacts between diets of exclusively *P. minimum* and mixed is critical to the derivation and application of the proposed chlorophyll a criteria. It is implicit in the criteria document that *P. minimum* effects on oysters are to be expected whenever the 3,000 cell/mL threshold is exceeded without regard to the availability of other food sources. We contend that *P. minimum* impacts on oysters can only be inferred where the threshold is exceeded AND *P. minimum* accounts for the great majority of the phytoplankton community assemblage biomass for an extended period.

An analysis was performed to assess the frequency of unialgal *P. minimum* occurrences, using CBP 1984-2000 monitoring data compiled by members of the chlorophyll team (Buchanan and others, 2002). For several different season and salinity combinations, samples were classified according to the proportion of the total phytoplankton biomass that was represented by *P. minimum*. The total number of samples falling into each category was divided by the total number of samples collected in that season/salinity combination. The results (Table 1) demonstrate that this condition (i.e. >95% *P. minimum*) has not been observed in the Bay or its tributaries. Even when viewing >50% dominance instead of >95%, this condition still was <u>never</u> observed in the oligohaline and polyhaline environments and observed only rarely in the mesohaline spring (~1% of observed samples). *P. minimum* was never observed to exceed 20% of total biomass in Virginia waters.

Table 1: Proportion of samples falling into different categories of *P. minimum* biomass dominance by season and salinity regime.
[based on 1984-2000 CBP monitoring data compiled by Buchanan and others, 2002]

Salinity Regime	Season	n	Ratio of *P. minimum* biomass to total phytoplankton biomass					
			0.00-0.25	0.25-0.50	0.50-0.75	0.75-0.90	0.90-0.95	0.95-1.00
OH	Spring	268	265/268 (98.9%)	3/268 (1.1%)				
	Summer	291	291/291 (100%)					
MH	Spring	717	684/717 (95.5%)	23/717 (3.2%)	9/717 (1.2%)		1/717 (0.1%)	
	Summer	903	900/903 (99.7%)	3/903 (0.3%)				
PH	Spring	238	238/238 (100%)					
	Summer	423	423/423 (100%)					
OH, MH, & PH	Spring	1223	1187/1223 (97%)	26/1223 (2.1%)	9/1223 (0.8%)		1/1223 (0.1%)	
	Summer	1617	1614/1617 (99.8%)	3/1617 (0.2%)				

The implication is that a chlorophyll *a* criterion on the basis of *P. minimum* is not warranted because the associated impacts on oysters due to this species were considered either absent or exceedingly rare as judged from a review of the literature and the plankton data set.

<u>*Practicality of Managing HABs*</u>: The fundamental implication of a *P. minimum*-based chlorophyll *a* criterion is that nutrient reduction to achieve the criteria will reduce the frequency or magnitude of *P. minimum* blooms. This is in serious question for several reasons. The ability to control HABs in general by nutrient management is more of a research topic than a proven practice at this time, and varies greatly according to the taxon and the environmental setting. Blooms occur in response to a complex set of ecological stimuli and are not necessarily predictable or manageable. As stated on p. 102 of the criteria document, "reductions in nutrients alone may not be effective in reducing the incidence of such harmful algal blooms". In fact, it is unknown if the magnitude of anthropogenic nutrient loads is a major factor in the occurrence of these blooms. There is no evidence that the frequency or magnitude of *P. minimum* blooms has either increased or decreased in the Bay system in response to historical changes in nutrient loads or concentrations.

Moreover, there is some reason to suspect that chlorophyll *a* criteria-driven nitrogen reductions might give *P. minimum* a competitive advantage and *increase* the bloom frequency of this taxon. *P. minimum* has a very low critical cell quota for nitrogen has been shown to be able to out-compete other phytoplankton groups as nutrients become limiting (Roelke and Buyukates, 2001). During low frequencies of nitrate supply, uptake and growth rate of *P. minimum* become uncoupled, and *P. minimum* is able to form a large internal pool of nitrogen that constitute a competitive advantage (Sciandra, 2002). Some authors (e.g., Hodgkiss and Ho, 1997) have concluded that nutrient ratios are more important than absolute nutrient concentrations at regulating dinoflagellate blooms. The optimal N:P ratio for growth of *P. minimum* is 4-13:1 (Hodgkiss and Ho, 1997). By comparison, the average DIN:DIP ratio in the Maryland mainstem Bay and tributaries is in the 20-40:1 range (Boynton and others, 1995). Reducing nitrogen to comply with a chlorophyll *a* criterion in the Bay system would actually shift the N:P ratio in favor of *P. minimum* blooms.

These findings call for extreme caution in the management applications of simple correlations of chlorophyll *a* and blooms of specific taxa. In reality, the current state of the science does not allow us to predict whether *P. minimum* bloom frequency would increase, decrease, or remain unchanged in response to chlorophyll *a* criteria-driven nutrient reductions. The reductions in chlorophyll *a* that will be driven by DO and water clarity standards provide an excellent opportunity to monitor and characterize bloom frequency and magnitude in response to nutrient load reductions. We recommend that HABs be tracked as part of an adaptive management strategy for the Bay system. But numeric chlorophyll *a* criteria based on the potential for HABs are not justified at this time.

Contributions to reduced light levels (pp 102), (pp 116)

We agree that contributions to reduced light levels represent a valid management concern related to chlorophyll a given its relationship to SAV as a designated use. The text associated with this section provided a good description of the trade-off between TSS and chlorophyll *a* as it relates to the diagnostic tool (Gallegos, 2001). Table V-7 also provides a good summary of the associated chlorophyll *a* levels needed to attain various water clarity application depths given a range of TSS. However, the manner in which this information was narrowed down to produce single chlorophyll a criteria values in Table V-10 was considered arbitrary and inappropriate. The approach involved the selection of 15 mg/l TSS (tidal fresh / oligohaline) and 10 mg/l TSS (mesohaline / polyhaline) at a 1m application depths as the necessary assumptions.

It is important to indicate that a determination of water clarity attainment depths, attainability of sediment reductions, and trade off between TSS and chlorophyll *a* are the domain of a larger State standards adoption process. Therefore, the ultimate designated uses and chlorophyll *a* concentrations associated with water clarity attainment are expected to vary widely between Bay segments. These difficult and complex issues cannot be resolved by the chlorophyll *a* document, and if retained would only serve to limit needed State flexibility in these areas. Our recommendation consists of the following: (1) retain the general description of the role of chlorophyll *a* to water clarity, and (2) indicate that the attainment of water clarity criteria will serve to address the associated impairments related to chlorophyll *a*. This is consistent with the STAC recommendation to provide a better connection between chlorophyll *a* and SAV while retaining the flexibility which will be needed to address the water clarity criteria.

Contributions to low dissolved oxygen conditions (pp 102)

Similar to our comments on the water clarity connections we agree that contributions to low dissolved oxygen represent a valid management concern related to chlorophyll *a*. Our concerns with the approach taken with this end point are that the results from the water quality model have been too broadly considered bay-wide. Also similar to the water clarity connections the chlorophyll *a* concentrations associated with DO attainment are also considered to vary widely over different seasons and bay segments. The approach taken to consolidate these results bay-wide is not consistent with the overall process. Our recommendation consists of the following: (1) continue to retain the general description of the role of chlorophyll *a* to low DO, and (2) indicate that the attainment of DO criteria will serve to address the associated impairments related to chlorophyll a. This is consistent with the STAC recommendation to provide a better connection between chlorophyll a and designated uses while retaining the flexibility which will be needed to address the DO criteria.

Strengths and Limitations of the Criteria Derivation Procedures (pp 102)

In the first paragraph of this section the authors note that *"These criteria must be based on sound scientific rationale and must contain sufficient parameters or constituents to protect the designated use. The chlorophyll* a *criteria presented here meet these definitions of water quality criteria*". For the many reasons stated in these comments it is VAMWA's position that the scientific basis of the chlorophyll a criteria does not serve to provide a defensible linkage between chlorophyll a and designated uses to justify the specific numerical criteria proposed in Table V-10. However, the information which has been presented to date is considered sufficient to support the narrative expression of chlorophyll *a*. As stated in our general comments our recommendation for righting the course consists of moving forward with a narrative chlorophyll *a* criteria alone and publishing the remainder of the technical information in a separate non-regulatory proceedings document. It is recognized, however, that States would need guidance in developing translators to interpret a narrative criteria. To fulfill this need we recommend that that consideration be placed on aesthetics and connections with attainment of water clarity and dissolved oxygen criteria.

In the second paragraph of this section the authors note that "*Given the role of chlorophyll* a *as a direct measure of phytoplankton biomass, it is not a chemical contaminant or stressor like a metal or low dissolved oxygen, respectively. At the same time, as desribed below chlorophyll* a *provides a direct measure of desired ecological conditions was well as the water quality impairments resulting form nutrient over-enrichment*". Our reaction is that we agree that chlorophyll *a* is an accepted measure of nutrient over-enrichment but it lacks the ability to determine the specific impairment threshold(s) on designated uses which is required of water quality criteria under the Clean Water Act.

In the third paragraph of this section the authors note that "*blooms of these phytoplankton species are also correlated with many other environmental variables that are not controllable by reductions in chlorophyll* a *(Tyler and Seliger 1981; Sellner et al. 2001)*. We concur but find that this limitation is inconsistent with the recommendation to propose a regulatory criterion. As discussed above, there is reason to believe that nitrogen reduction could actually increase the competetive advantage of certain taxa such as *P. minimum*. Similar to the mesozooplankton issues more research and development is needed to address these questions. Such foundation level questions were not considered compatible with the recommendations to move forward with the numeric proposal.

Additional criteria sections needed (no page number)

Nuisance Bloom-Based Methodology: This chapter should include a section that describes methodologies for deriving chlorophyll *a* criteria to protect against nuisance blooms. In fact, a placeholder for such a subsection was in the last version of the criteria document discussed by the Chlorophyll Team (labeled as the 11/15/02 draft), but it was not present in the draft distributed for this round of review. Attempts to relate chlorophyll *a* to living resources as a designated use (other than DO and clarity linkages) has proven very difficult from a technical standpoint despite the best efforts of the task group. However, aesthetics are considered an acceptable designated use under the Clean Water Act. This represents an alternative approach to circumvent these problems associated approaches attempted to date related to biology.

As the Chlorophyll Team has discovered, there is remarkably little prior research upon which to link chlorophyll *a* concentrations and aesthetic conditions in estuarine settings. Some states have set bloom-related numeric targets for tidal/coastal regimes, but the targets have either been either derived from lake studies (e.g., the 40 µg/L criterion of North Carolina; see http://www2.ncsu.edu/ncsu/CIL/WRRI/news/ma01chlorophylla.html) or based on a semi-arbitrary judgment of the state agency (e.g., the 50 µg/L criterion used by Maryland for TMDL allocations). Although the origin of the 50 µg/L value used by Maryland is not completely clear, the likeliest source is an early USEPA report on the Potomac Estuary (Jaworski, Clark, and Feigner, 1971) that stated:

> "Subsequent and continuing observations...have confirmed persistent, massive blooms of the blue-green algae *Anacystis* [*Microcystis*] in nuisance concentrations of greater than 50 µg/L..."

A report on the 1983 *Microcystis aeruginosa* bloom on the Potomac River (MWCOG, 1984) provides some support that surface scums of this taxon were observed when chlorophyll *a* concentrations exceeded ranged from about 50 µg/L to over 200 µg/L. The USEPA Nutrient Criteria Technical Guidance Manual for Estuarine and Coastal Marine

Waters (USEPA, 2001) does not provide specific chlorophyll targets but cites 60 µg/L chlorophyll *a* as an example of a potential criterion (see Table 7-1 of reference). Taken in sum, these values suggest that chlorophyll *a* targets to protect against nuisance blooms might be 10-30 µg/L higher than those presented in the draft criteria document as "protective against excessive/harmful algal blooms". However, none of these values was based on a study specifically designed to identify chlorophyll *a* concentrations at which a bloom becomes a "nuisance".

We have recommended specific text that describes how states should design and conduct user perception surveys and algal condition assessments to support numeric chlorophyll *a* targets.

References

Boynton, W.R., J.H. Garber, R. Summers, and W.M. Kemp. 1995. Inputs, transformations, and transport of nitrogen and phosphorus in Chesapeake Bay and selected tributaries. Estuaries, 18(1B):285-314.

Fulton III, R. S. and H. W. Paerl. 1987. Toxic and inhibitory effects of the blue-green alga *Microcystis aeruginosa* on herbivorous zooplankton. *Journal of Plankton Research* 9 (5):837-855.

Fulton III, R. S. and H. W. Paerl. 1988. Effects of the blue-green alga *Microcystis aeruginosa* on zooplankton competitive relations. *Oecologia* 76:383-389. Lampert, W. 1981. Inhibitory and toxic effects of blue-green algae on *Daphnia*. *Int. Rev. Gesamten Hydrobiol.* 66:285-298.

Hodgkiss, L.J. and K.C. Ho. (1997). Are changes in N:P ratios in coastal waters the key to increased red tide blooms? Hydrobiologia 352: 141-147.

Luckenbach, M.W., Sellner, K.G., Shumway, S.E. and K. Greene. 1993. Effects of two bloom forming dinoflagellates, *Prorocentrum minimum* and *Gyrodinium uncatenum*, on the growth and survival of the eastern oyster, Crassostrea virginica. Journal of Shellfish Research 12 (No. 2): 411-415.

Roelke D. and Y. Buyukates (2001). The diversity of harmful algal bloom-triggering mechanisms and the complexity of bloom initiation. Human and Ecological Assessment. Vol. 7, No. 5, pp. 1347-1362.

Sciandra, A. (1991). Coupling and uncoupling between nitrate uptake and growth rate in Prorocentrum minimum (Dinophyceae) under different frequencies of pulsed nitrate supply. Marine Ecology Progress Series. Vol 72: 261-269.

Sellner *et al.*, 2001. (From Chapter V Chlorophyll a Criteria. No full reference)

Tyler, M.A. and H.H. Seliger. 1981. Annual sub-surface transport of a red tide dinoflagellate to its bloom area: Water circulation patterns and organism distributions in the Chesapeake Bay. *Limnol. Oceanogr.* 23: 227-246.

Virginia and Maryland Associations of Municipal Wastewater Agencies, 2002, Technical review comments on the May 2002 draft ambient water quality criteria for dissolved oxygen, water clarity, and chlorophyll a for Chesapeake Bay and tidal tributaries, 51 p.

Wikfors, G.H. and R.M. Smolowitz. 1995. Experimental and histological studies of four life-history stages of the eastern oyster, *Crassostrea virginica,* exposed to cultured strain of the dinoflagellate *Prorocentrum minimum.* Biol Bull: 188-329.

2C. Recommended Implementation Procedures—Chapter VI

V/MAMWA generally supports the cumulative frequency distribution (CFD) approach to criteria assessment for parameters for which a biologically-based reference curve can be derived. Despite its relative complexity, we consider this to be a logical approach for determining the allowable frequency and area of exceedances, and superior to the use of an arbitrary 10-percent value. Our comments below reflect both support for specific implementation procedures and recommendations for adjustment/improvement. We have also provided an edited version of Chapter VI to reflect our recommendations.

1. Removal of references to percent-light-at leaf (p. 132): The chapter states that "*In habitats with very shallow water with high nutrient concentrations but with less turbidity, epiphytes can be the principal source of reduced light. There are locations in Chesapeake Bay tidal waters where epiphytic growth plays a role in light attenuation at levels significant enough to influence the difference between survival and lack of underwater bay grasses only. In these specific shallow water-water habitats, states should consider applying light at the leaf criteria.*" In most cases the light available to SAV as measured by percent light through the water serves to limit epiphytes as well resulting in a moot issue regarding epiphytes. On the other hand we tend to agree in concept that nutrient driven epiphyte accumulation has potential significance under the limited conditions described. The general level of guidance provided, however, does not contain a sufficient level of detail advise the states in a practical manner regarding the specific CBP segments, seasons, or attainment depths the light at the leaf (PLL) criteria should apply. Another consideration involves the absence of reference curve development pertaining to PLL. There are also significant and recognized technical uncertainties regarding the nutrient epiphyte response given variations in light attenuation, TSS, and biological grazers. These issues are acknowledged in Chapter IV and Batiuk et al (2000).

Given the limited understanding of these issues at the present time we recommend that Chapter VI reflect that the water clarity criteria should be implemented as percent-light-through-water (PLW) only. This recommendation is also consistent with WQ Steering Committee discussion where concerns have been expressed over the existing data limitations and the high costs of new monitoring given the questionable need for PLL over PLW. Percent light through water (PLW) is easier to implement and is less costly than PLL since nutrient and sediment data are not needed. Further research is still considered warranted, however, to further investigate (1) those limited areas potentially in need of light at the leaf criterion, (2) the additional information gained from a consideration of epiphytes over PLW alone with respect to SAV survival, (3) a validation of the epiphyte model with site specific field data for the needed segments, and (4) reference curve development for PLL. Using these results light to leaf components could be added to criteria implementation in a future review of water quality standards if needed and serve to focus additional monitoring (and associated expenses) to assess light to the leaf only where needed.

2. Removal of references to numeric chlorophyll *a* criteria; need for greater flexibility for chlorophyll *a* implementation procedures (p. 132-133): Consistent with our comments on the chlorophyll *a* criteria, we recommend removal of references to numeric chlorophyll *a* criteria in Chapter VI. This section should acknowledge that chlorophyll *a* criteria are expressed in narrative format only and that specific numeric targets may be developed by the states.

3. Need for greater flexibility for chlorophyll *a* implementation procedures: As a narrative criterion, the chlorophyll *a* criteria is fundamentally different from the DO and water clarity criteria. Specific numeric targets may be highly segment-specific, designed to protect against impairments that have not yet been fully investigated (e.g., aesthetics), or used as a back-up to DO and water clarity criteria. With this flexibility in mind, states could pursue different implementation procedures for chlorophyll *a* that may or may not be similar to those described in the draft document. For example, in a later comment we describe an adaptive management approach that involves tracking of chlorophyll *a*-related impairments in parallel with DO and clarity-driven load reductions. As such, the text of Chapter VI should indicate greater flexibility with regard to how the chlorophyll *a* criterion might be implemented. Our recommended edits reflect this comment.

4. Interpolation of water quality monitoring data (p. 140): In several places of the text the terms "interpolation" and "extrapolation" are used inter-changeably when explaining how water quality estimates are made where real data is not available. The two terms describe very different processes for estimating conditions. *Interpolation* occurs between known data points while *extrapolation* occurs outside of data points. The latter case is illustrated where conditions are predicted for near-shore waters when data is only available for stations further from shore. The criterion approach must be limited to only *interpolation* because of the uncertainty associated with assuming a relationship where one has not been documented. Laboratory results are not valid unless the result falls within the concentrations tested (the standard curve, for example). The same should hold true for predictions of conditions where the relationship between space, time and magnitude is unknown.

5. Critical importance of designated use boundaries (associated with developing the cumulative frequency distribution, pp. 141): A description of the designated uses and methods used to delineate these uses are described in the draft "*Technical Support Document for the Identification of Chesapeake Bay Designated Uses and Attainability – dated December* 2002". These issues need to be identified as a critical part of the implementation procedures as well in order to assign the cells in the interpolator to the correct designated uses and/or layers. For example, with regard to DO, analyses done by the Modeling Sub-Committee have found that different calculation methods of pycnocline depth (i.e. as a long term averaged pycnocline depth vs individual pycnocline depth) has a large influence on the attainability of the designated use and the associated loadings. Other issues are also outstanding with regard to the geographical assignment of open, deep, and deep channel habitats as well as attainment depths for water clarity. Obviously, firm definitions of the designated use boundaries, both vertically and geographically are needed before the monitoring results can be assigned to the interpolator in order to properly construct the assessment unit CFD and to set the stage for the associated statistical tests for attainment. Although this is a work in progress, the implementation procedures should reference the establishment of designated use boundaries as a step needed before water quality monitoring data interpolation. The procedures should also indicate that flexibility is to be afforded to the States in the establishment of these important boundaries. Recognizing that these designated uses will remain in flux for some time in the future, each draft assessment should document the specific designated use boundaries involved and the methods used to establish them. Final interpretations of attainment will require State adoption of the specific use boundaries.

6. Other information is needed to accompany cumulative frequency determination graphics. In addition to the segment and season, other pertinent information is needed to evaluate the significance of the results and to place them into overall context. This other useful information should consist of (1) the size of the designated use , as surface area or volume, (2) the percentage of the total habitat which is represented by the designated use. This particular data is especially needed for the vertical layers of the DO assessment. Information is needed to understand the relative percentage of the total habitat which is accounted for by the open water, deep water, or deep channel habitat within the entire water column. As a hypothetical example, if the deep water use was found in non-attainment at a rate of 50% but only accounted for 2% of the total habitat of the water column, the management actions would be different than if the deep water use accounted for 75% of the total habitat. Although this type of information may not lead to clear answers it may prove useful as another source of data if difficult judgement calls must be made.

7. We agree that non-attainment should be judged by statistical testing of the CFDs and reference curves (p. 146-148): There are cases when the CFD assessment curve is partially above and partially below the reference curve. During discussions in the allocation team and elsewhere the "stop-light plots" have been judged in non-compliance even if the total area under the CFD assessment curve was less than the area beneath the reference curve. For example, the assessment curve might take the form shown on Figure 1. As previously mentioned the segment would falsely be considered in non-compliance due to the red area where the assessment curve wanders above the reference curve, but not fully consider the green area where the assessment curve is beneath the reference curve. We agree that a segment should not be considered in non-compliance unless the total area above the assessment curve significantly exceeds the total area beneath the reference curve. This view is consistent with statements contained on pp 146 and pp 149 in the guidance where it was stated that "*The area under the curve is recommended as the basis for defining criteria attainment for all Chesapeake Bay segments and designated uses*" and "*the Ks test appears to offer strong potential for the purpose of evaluating water quality criteria attainment in Chesapeake Bay*". Our point regarding this comment section is that these concepts need to be better communicated to the managers involved in the allocation discussions.

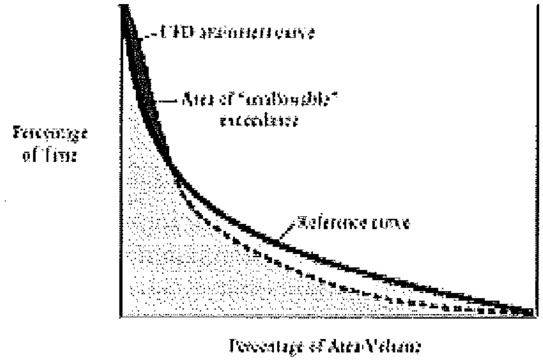

Figure 1: Interpretation of CFD reference curve as described in December 2002 version of draft criteria document.

This issue is likely to be important in segments that have attainment curves close to the reference curves, and thus low rates of exceedance. However, modeling has shown the exponential nature of load reductions needed to completely eliminate the last bit of "red" area on stoplight plots for some segments. Thus, it could be important in the proper direction of resources to achieve goals of the Chesapeake Bay 2000 agreement. We support the concept of statistical testing to determine if a CFD attainment curve departs significantly from the reference curve.

8. Additional work is needed to evaluate statistical tests for attainment: We support the use of statistical tests to determine if the CFD attainment curve is significantly different than the reference curve. The use of Kolmogorov-Smirnov test alone is problematic because it compares the curves based only on their maximum differences and thus is very sensitive to differences in the shapes of the curves, as opposed to the total area under the curves. As stated on p. 147 of the document, It is recommended that the shape of the curves be used for diagnostic purposes only. Decisions regarding full attainment should be based the overall amount of criteria exceedence indicated by the area under the curve. Thus, the use of the Kolmogorov-Smirnov test could lead to errors in conclusions regarding attainment. Alternative tests include the chi-square two sample test and the Mann-Whitney U test. Ideally, the test should consider variability in both the original reference data set and data from the segment being assessed. We look forward to working with the Bay Program to identify the most appropriate statistical testing method. In the meantime, we recommend that no preference for the Kolmogorov-Smirnov test be stated in the document.

9. Reference curves for dissolved oxygen criteria, open water, deep channel (p.152-154): The open water reference curves are based on distributions of data for various Bay segments. It is unclear, however, whether the Bay segments sampled are representative of all that will be assessed. For example, if data from the Elizabeth River were not used to develop the reference curves, those reference curves may not be appropriate assessing DO attainment for this river; particularly if this river deviates from other water bodies in the distributions of TP, TN, TSS and chlorophyll a. The approach must ensure that the data used to development of these reference curves was not censored prior to development. If censoring took place, then the waters omitted in the analyses should be listed and text provided stating that reference curves specific to these waters must be developed to determine attainment for these waters.

The text for the deep channel section indicates that a reference curve will not be used to determine attainment in this habitat. However, the text also fails to describe the degree of exceedance required to conclude that the uses in this habitat are not supported. This must be addressed prior to finalizing the chapter.

10. Addressing gross-level misconnects between non-attainment and SAV success: As mentioned in our comments on the water clarity criteria (Chapter IV), there appears to be a mismatch between non-attainment of the water clarity criterion and the presence/increase of SAV in some low-salinity segments. The mismatch is acknowledged in Chapter V (p. 81) by reference to Batiuk and others (2000), who noted that in tidal freshwater and oligohaline segments:

- The median values of percent light-at-the-leaf at the 0.5 meter and 0.1 meter depths were "far below the minimum light requirement" in low-salinity segments that supported SAV at those depths.
- Positive increases in bay grasses occurred in low-salinity segments "even when the median percent light-through-water was considerably less than the minimum requirement."

As stated on p. 83 of Chapter IV:

> There is a general need to for a better understanding of the minimum light requirements for the survival and growth of [SAV] as well as the influence of other environmental factors...The area that remains most problematic is minimum light requirements for turbid, low-salinity habitats...

The clarity team's efforts to derive a biologically-based CFD curve have underscored the potential regulatory consequences of this mismatch (Olson, 2002). CFD attainment curves were derived for different reference segments that had "good" SAV coverage based upon having at least 25-percent coverage of the available habitat within the target depth contour. Although the CFD curves for mesohaline and polyhaline segments were clustered in a reasonable fashion, the CFD curves for tidal freshwater and oligohaline segments were widely spaced and covered the full range of potential exceedance rates (Figure 2):

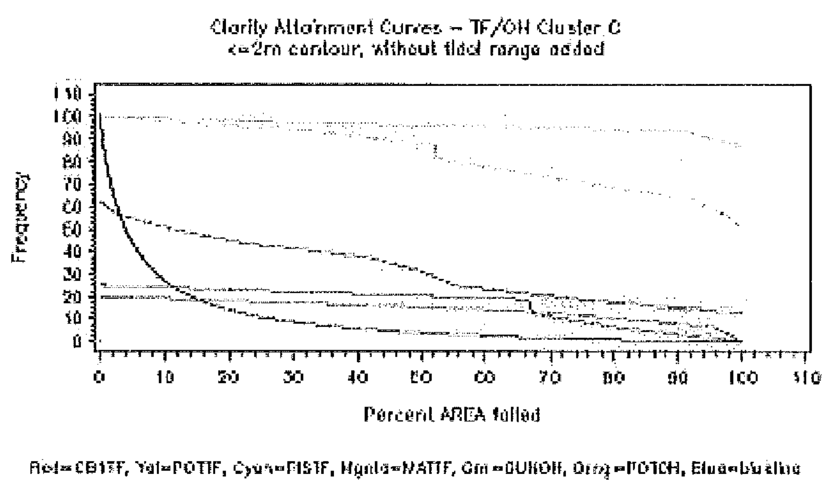

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Figure 2: Example of CFD attainment curves of reference TF/OH segments with "good" SAV coverage, from clarity team materials.

The clarity team ultimately selected the central curve (from CB1TF) from Figure 2 as the "biologically-based reference curve". This appears to put segments POTOH, POTTF, and PISTF in extreme non-attainment of water clarity criteria, despite being selected as reference segments based on SAV success. For example, the tidal freshwater Potomac River has experienced a "resurgence of 12 bay grass species" (p. 80) yet its CFD curve is so far above the reference curve that it is questionable whether it could ever come into compliance with the water clarity criterion, regardless of how successful SAV are in that segment.

The implication of the wide spacing of CFD curves in Figure 2 is that the recommended reference curve is not a useful predictor of SAV success in many low-salinity segments. This would be understandable for segments that have high rates of attainment but little SAV, because it is known that many other factors besides light availability can limit SAV growth. But the reverse phenomenon (low attainment rates coinciding with SAV success) is problematic from a regulatory perspective because it will result in the 303(d) listing of segments that are actually meeting the shallow water/SAV use.

Reasons for the mismatch: Following are potential reasons that CFD curves might show very low rates of attainment of the water clarity criteria, despite having abundant, persistent, and increasing SAV coverage:

- The criterion itself (13 percent light through water) may exceed the actual light requirement of many freshwater SAV taxa.
- Canopy formation allows many SAV taxa to concentration their photosynthetic tissues much higher in the water column than the total water depth that would be used in the PLW calculation [equation IV-1 (p. 86)].
- Relatedly, the SAV community might be dominated by canopy formers or by species with lower light requirements, rather than the diverse community that was historically present.
- CFD curves based on mid-channel data may not reflect near-shore improvements in water clarity caused by the grass beds themselves.
- Established grass beds require less light than is needed for the revegetation of barren areas.

To again use the Potomac tidal freshwater as an example, the "resurgence of 12 bay grass species" suggests that light availability is able to support a diverse community of species. The mismatch is more likely related to differences in mid-channel/nearshore water quality and by conservativeness of the criterion when applied to low-salinity areas with established grass beds.

Recommended Solutions:

1. *Refine the criteria values*: We support the stated intention to refine the water clarity criterion itself based on additional field and laboratory measurements of minimum light requirements of SAV, especially for species that grow in turbid, low-salinity environments (p. 83, under "Areas for Refinement").

2. *Use nearshore data*: We support the stated preference for nearshore data to assess compliance, and the use of SAV presence/absence to identity "gross level misconnects between [SAV] and mid-channel information." (p. 165-176).

3. *Allow site-specific modifications to the reference curve*: A "gross-level misconnect" between SAV and criteria attainment calls for segment-specific modification of the criterion (as suggested on p. 167 of the criteria document), the effective depth of application, or the CFD reference curve. Although any of these three options might be warranted in particular circumstances, modification of the reference curve is the most straightforward and least burdensome (some a regulatory standpoint) option in the general case of high rates of non-attainment coincident with abundant, persistent, and diverse SAV.

For segments that are deemed to be in non-attainment with the water clarity criteria, an examination should be made of SAV success in that segment over the three-year assessment period, in a manner that is consistent with how the original "biologically-based reference curve" was derived—e.g., at least 25-percent coverage within the target depth contour. If appropriate, this quantitative measurement should be supplemented with professional judgment regarding the desirability of the SAV community; for example, to ensure that it is not composed only of *Hydrilla*. The coverage should also be examined to ensure that SAV abundance was not systematically decreasing over the 3-year assessment period.

If the segment meets the conditions above to qualify as region of SAV success, its CFD attainment curve should be considered a reference curve for that segment. This will have the effect of bringing that segment of demonstrated SAV success into compliance with the water clarity criterion for that assessment period. The modified reference curve will provide a baseline for the assessment of compliance in future assessment periods.

It should be noted that there are other potential bases for evaluating "SAV success", such as the SAV restoration goals. We believe that the SAV restoration goals should remain non-regulatory and are not recommending the development of biocriteria *per se*. Rather, the regulatory evaluation of SAV success should remain consistent with the quantitative guidelines developed for the derivation of biologically-based reference curves. It is probable that non-regulatory SAV restoration goals will be different than these guidelines in many segments.

Our edits to Chapter VI reflect the recommendations above.

11. Drop the presently proposed chlorophyll *a* reference curve (p. 155-156): As discussed in our comments on Chapter V (Chlorophyll *a* Criteria), the chlorophyll *a* criteria should be expressed in narrative format only since the proposed numeric 304(a) criteria are categorically unsupported. The inclusion of a numerical table of chlorophyll a criteria (Table VI-3) is also inappropriate in this section for the same reasons. They do not represent valid 304(a) numerical criteria or an appropriate means to interpret / translate the narrative statement as written.

Further consideration of specific CFD reference curves for chlorophyll *a* should be delayed until the criteria magnitude is nailed down. The chlorophyll *a* reference curve discussed on p. 155-156 and Appendix F is not a valid, "biologically-based" reference curve because it is derived from methods (i.e. phytoplankton reference community) acknowledged in the process to lack demonstrable relations between chlorophyll *a* and impairments of designated uses. There is no evidence that data from the excluded "bins" did not support aquatic life uses, or that exceedance of the cited chlorophyll *a* values actually corresponded to impairment of aquatic life uses. Obviously, without an understanding of how chlorophyll a manifests itself as an impact on biology it isn't possible to define the conditions absent of the impact either. Problems with the inability to tie chlorophyll a to specific designated use impairments have served to cascade throughout the proposed criteria process.

We recommend the deletion of Appendix F and the revision of discussion on p. 155-156 to state that reference curves for chlorophyll *a* cannot be derived at the present time. However, they may be possible in the future. If a state chooses to derive numeric targets to protect against nuisance blooms, reference curves could be developed based on the chlorophyll *a* concentration in segments that do not experience such blooms. Our edits to Chapter VI reflect this recommendation.

12. Spectral analysis and the logistic regression approach, (pp.159-164): The text acknowledges that these approaches have not been finalized or validated. Therefore VAMWA recommends that the text addressing these approaches be deleted until they or other approaches have been validated and finalized. Although inclusion of such information shows how the process of attainment could be conducted if these approaches are validated, draft approaches to attainment should not be included in criteria documents proposed for adoption as standards.

13. Chlorophyll *a* and Adaptive Management: The history of efforts to derive numeric chlorophyll criteria have led us to believe that this constituent would be best addressed by adaptive management. Adaptive management is a systematic, iterative process of setting goals, taking actions, evaluating results, and adjusting goals. It is particularly appropriate for situations (as with chlorophyll *a* management) in which a high degree of uncertainty exists between implementation and ecological responses. USEPA, Virginia DEQ, and other agencies have endorsed this as a common-sense approach to environmental management.

As discussed in these comments, it is highly questionable at this time as to whether numeric chlorophyll *a* targets provide any additional protection to designated uses than is provided by the DO and water clarity criteria. On the other hand, significant chlorophyll *a* reductions are expected throughout the Bay system as a result of DO and water clarity standards; these constituents are inextricably linked. Implementation of DO and water clarity standards provides the states with an excellent opportunity to monitor changes in chlorophyll *a*, HAB frequency/magnitude, aesthetics, etc. and further evaluate the benefits of numeric chlorophyll *a* targets. State WQS must be reviewed and revised as necessary every 3 years as part of the Triennial Review process. This existing process provides a sufficient opportunity to use adaptive management techniques along with on-going research. This process coupled with adaptive management described would help better define the appropriate linkages between numerical chlorophyll a concentrations and the designated uses.

In our edits we have recommended specific text to present adaptive management as a legitimate implementation procedure for chlorophyll *a*.

2D. Recommended Criteria Attainment Diagnostic Procedures – Chapter VII

Chapter VII provides a useful summary of various factors that should be considered when diagnosing the reasons for non-attainment of water quality criteria. In addition, much of this information provides a foundation for future work to further refine designated uses, if needed. Following are our specific comments on this chapter:

1. *Revision of title (p. 1)*: We recommend that the title of Chapter VII be changed to "*Natural Processes and Diagnostic Procedures for Non-Attainment*". The present title does not accurately describe the contents of Chapter VII. Rather, it describes procedures for evaluating attainment of the criteria—a topic that is actually addressed in Chapter VI. In addition, the first part of chapter VII does not involve actual diagnostic procedures or tools, but general discussion of natural processes that affect water quality. The revised title suggested is more descriptive of the chapter's true contents.

2. *Lack of support for SAV uses in turbidity maximum zones (p. 181)*: The subsection entitled "Estuarine Turbidity Maximum Zones" correctly points out that these zones have naturally low water clarity. However, this phenomenon has not yet been adequately addressed by "the selection of water clarity criteria application depths" as stated in this subsection. In fact, most of these areas have been assigned a default application depth of 0.5 m, despite that clarity levels to meet that depth are probably unattainable due to the natural turbidity effects described. A review of Figure VII-1 and the water clarity attainment depths shown on Exhibit 4-26 (pp 4-48 of the Technical Support Document) shows that the oligohaline segmentation is similar but not identical to the delineation of turbidity maximum zones. Our recommendation consists of establishing the turbidity maximum zones shown on Figure VII-1 as "no-grow zones" where no grasses have been mapped by survey. This recommendation argues for site-specific exceptions nested within the presently proposed segmentation scheme. Similar comments are also provided regarding the "Draft Technical Support Document for the Identification of Chesapeake Bay Designated Uses and Attainability".

3. *Revisions to "Naturally Elevated Chlorophyll* a *Concentrations" (p. 183)*: We support the discussion of factors (poor flushing, channel morphology) can naturally elevate chlorophyll *a*. However, we have recommended several edits to this subsection to reflect that: (1) the chlorophyll criterion is narrative, with several potential methods for translation into numeric targets; (2) to date, analyses to support chlorophyll criteria have been focused on well-flushed open water systems—the numerous poorly flushed tidal creeks and embayments have not yet been explicitly considered; (3) natural elevation of chlorophyll *a* in poorly flushed systems should be considered when setting use boundaries; and (4) it is not understood if anthropogenic nutrient loading is a major factor in the incidence of most types of HABs that occur in the Bay system. These complex issues (in addition to the many technical comments) further magnify the need for a narrative chlorophyll a criteria and the use of a flexible system of adaptive management by states regarding numerical targets.